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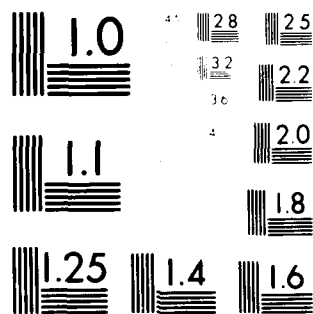
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Research and Development Technical Report

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ADVANCED AN/TPQ-37 TRANSMITTER TUBE.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this program is to improve the performance and reliability of the AN/TPQ-37 transmitter tube. The task is to build and test two high power, PPM focused, grid pulsed Traveling Wave Tube (TWT) that meet the requirements of Technical Guidelines MW-119B. The TWT will employ a M-type cathode for reduced temperature operation and extended life. Gain variations will be minimized by use of in-band loss techniques and weight will be reduced by using samarium cobalt magnets.		

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INTERIM REPORT
VTR-5720 TWT

SUMMARY

The Statement of Work calls for modification of an existing TWT primarily consisting of addition of an isolated anode electron gun and re-packaging to make it mechanically interchangeable with the outline drawing.

The VTR 5720 coupled cavity Traveling Wave Tube is a modification of one of the VTS 5754 family of PPM focused coupled cavity Traveling Wave Tubes developed in-house. These tubes are grid pulsed and PPM focused with samarium cobalt magnets. The tubes are liquid cooled with a water glycol mixture and each pole piece is individually cooled for thermal stability at high duty factor. The only circuit changes will be a 1% change in the period in order to provide flat gain at the increased power level. No changes will be required in the PPM stack since the added length will be obtained through increased thickness of the pole pieces.

The incorporation of the isolated anode turned out to be relatively straightforward due to the long focal length electron gun used on the existing tube. The majority of the magnetic redesign was associated with obtaining adequate shielding for the Brillouin focused electron gun. This was achieved by placing an iron cylinder inside of the vacuum around the isolated anode support.

The mechanical interchangeability was achieved by adjusting the length of the beam shaver in order to increase the length of the tube to meet the specification. The period of the driver circuits was increased to provide flat gain at the specified power level.

Electronically, the first tube worked quite satisfactorily with very flat power output at the specified level and duty factor. The phase linearity had not been measured at the time this report was prepared due to failure of the phase gear, but no problem is anticipated due to the minimal signal gain ripple.

The tube fails to meet full specification due to excessive collector-to-body interelectrode capacitance which was a result of redesign of the collector entrance conditions. Further work on the collector to body capacitance is currently in process.

DISCUSSION

The configuration of the isolated anode was determined by the allowable outline drawing and the magnetic shielding of the cathode required for Brillouin focusing of the electron beam. The inclusion of the isolated anode was facilitated by the long focal length of the existing electron gun. No changes were required in the electrostatic optics. The 99.8% shielding was achieved by insertion of a magnetic shield inside of the anode insulator and outside of the anode support cylinder (Figure 1). The insulator assembly is heliarc welded to the TWT body and the cathode support assembly is welded into the insulator for ease of assembly and future rebuilding.

A test vehicle was assembled to permit shock and vibration testing of the entire gun assembly. The tube had been previously environmentally qualified. The test vehicle included a small collector and VacIon[®] pump to permit determination of the beam transmission through the anode before and after the environmental testing (Figure 2).

The beam transmission through the anode was 99.98% before and after, indicating no deformation of the structure (Figures 3 and 4). The prototype tube was constructed with an identical gun assembly and with a few minor modifications to the existing tube design, as was discussed in the technical proposal. The period of the driver circuits was increased a small percentage to compensate for the increased beam voltage required for the higher power output. The collector entrance optics were changed to accommodate the 40% depression required by the specification.

The hot test data on the prototype tube was very encouraging. The power output is quite flat and the small signal gain has low ripple which promises equally low phase ripple (Figure 5). The phase was not measured on

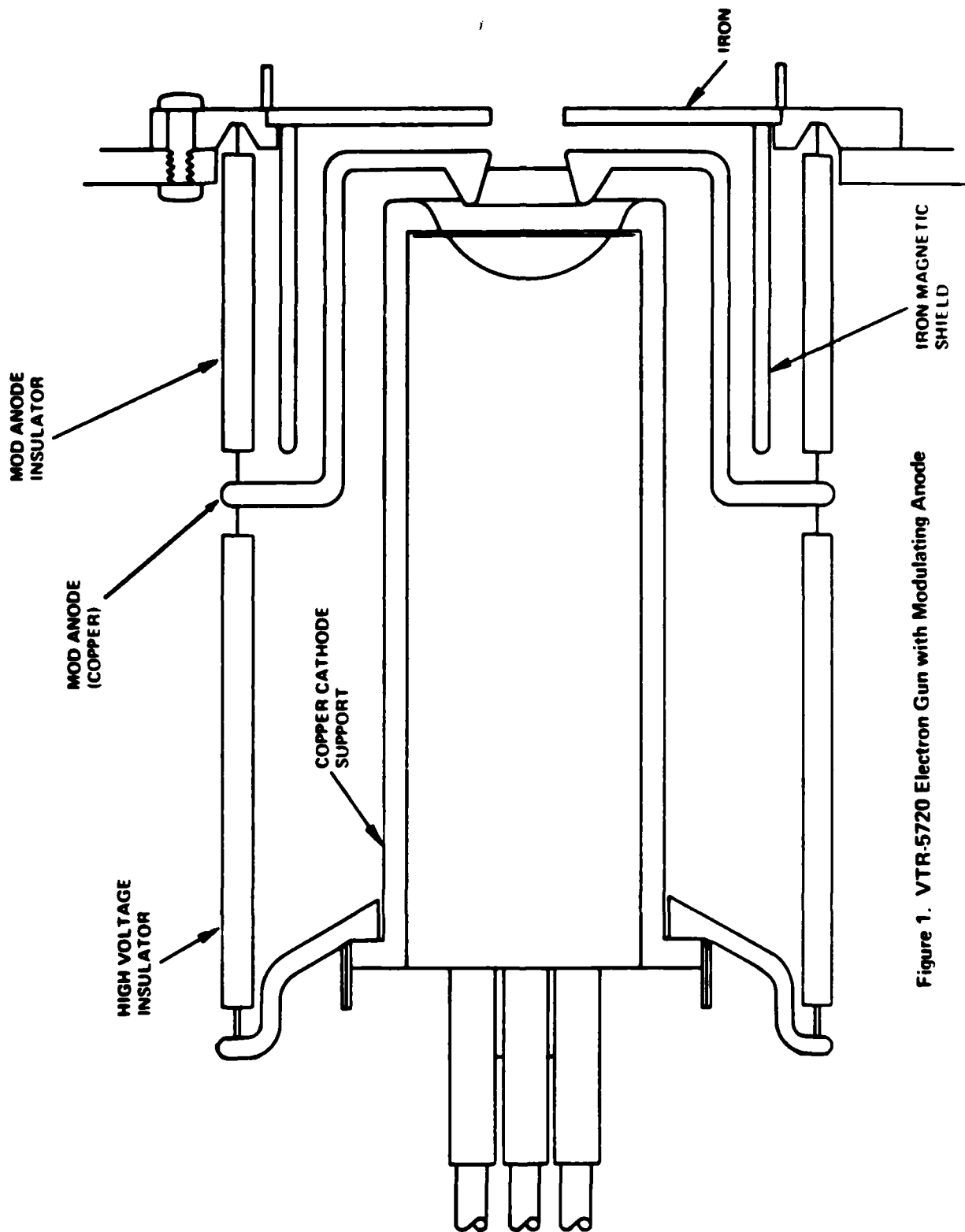
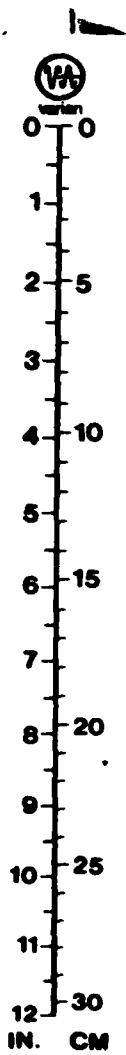


Figure 1. VTR-5720 Electron Gun with Modulating Anode

Figure 2. Tetrode Test Vehicle



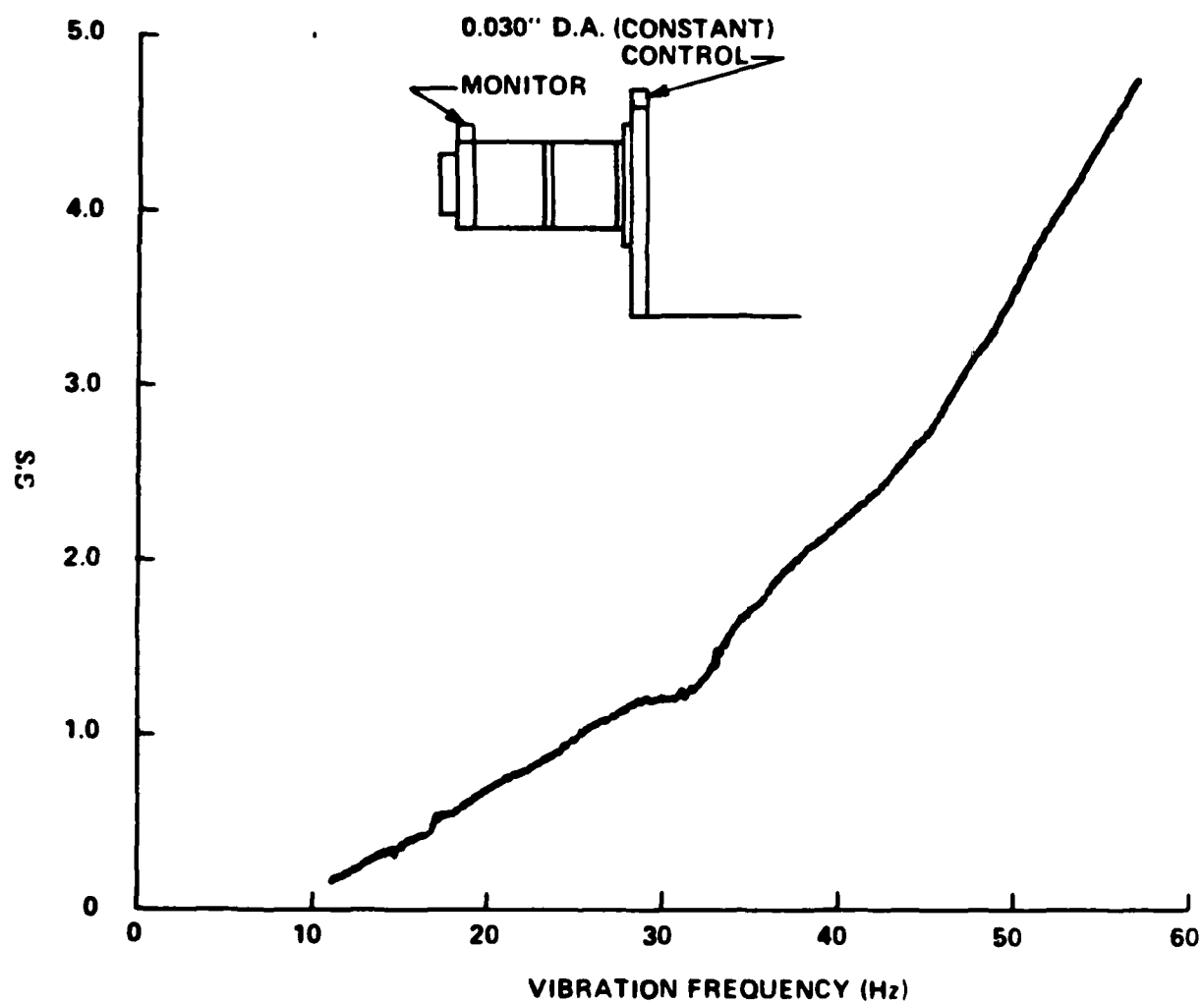


Figure 3. VTR-5720 Tetrode Vibration Profile

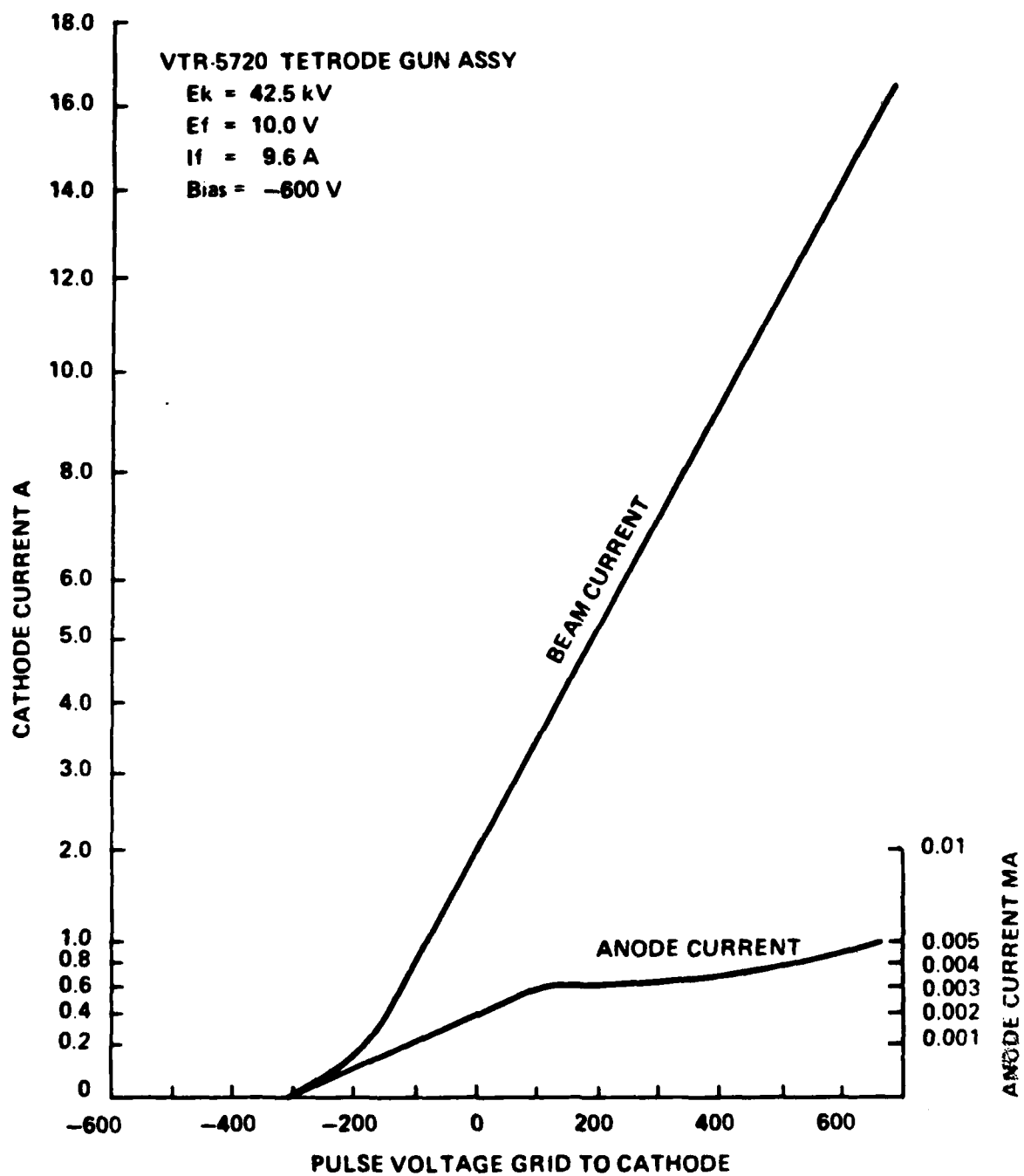


Figure 4. Beam Current as a Function of Grid Voltage

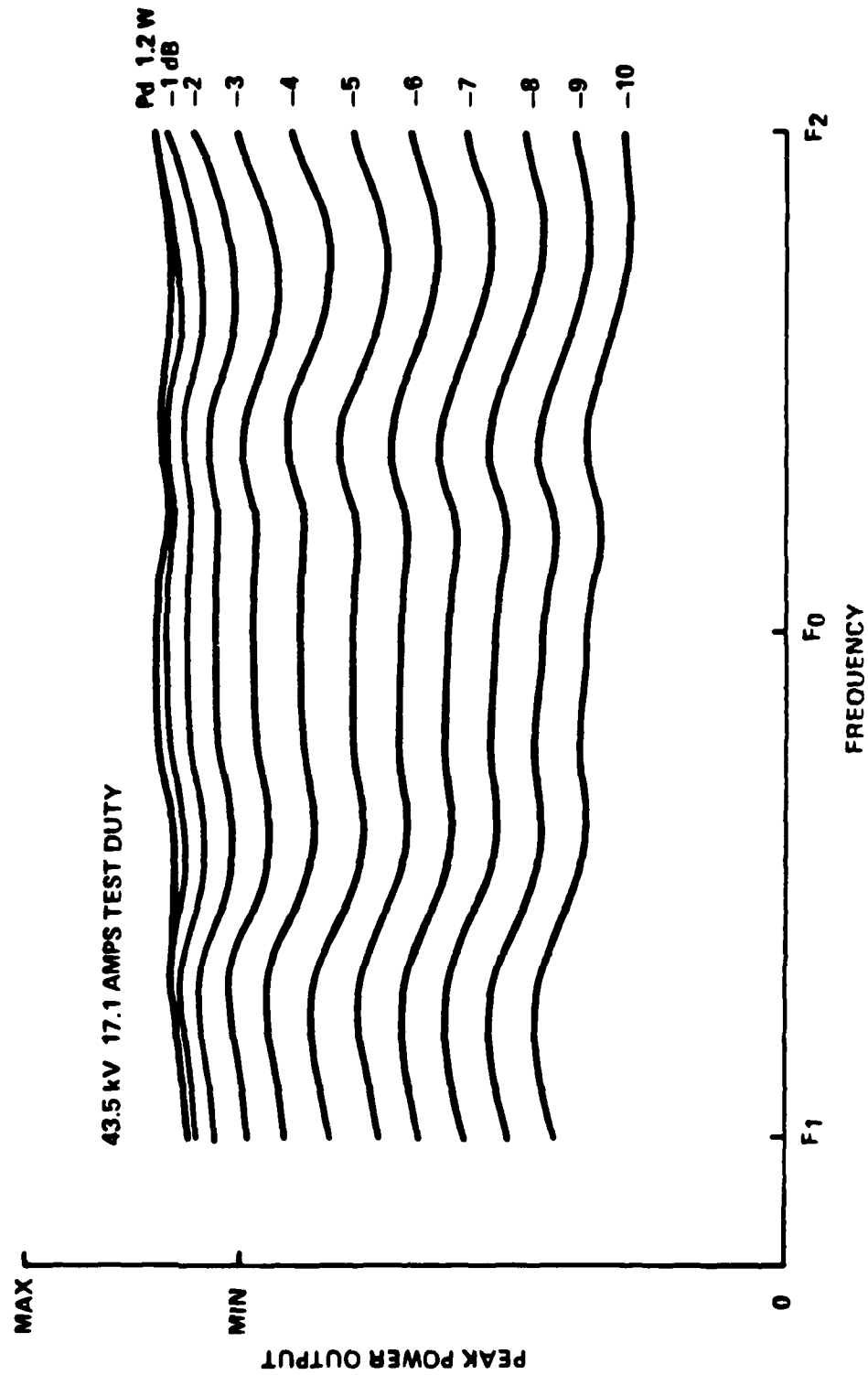


Figure 5. VTR-5720 TWT Power Out with Various Drive Levels

the first test due to failure of the diodes in our Wiltron phase measuring equipment. The small signal gain ripple is estimated to be 0.2 dB.

Since 1 dB peak to peak gain ripple will result theoretically in a 7° peak to peak ripple, the expected phase ripple will be 1.4° peak to peak. If, however, the majority of the gain ripple is in the output circuit the saturation effects will reduce the phase ripple to a degree similar to the saturated gain ripple as shown in the top curve.

The only known defect in the tube at this time is that the collector interelectrode capacitance is greater than the 100 picofarads allowed by the specification. At the time the tube was assembled we were under the impression that a change in specification to 200 pF was going to be granted. At the present time we are studying the problem further for incorporation in the next tube, or the rebuild of the first tube.

The statement of work also requires use of a cathode which operates at a temperature of at least 50°C less than the standard dispenser cathode. Varian's materials research group has developed the capability to osmium coat the standard dispenser cathode to reduce the work function and afford operation at substantially reduced temperature. We have had the opportunity to compare identical cathodes with and without coating in the same tube type.

The minimum operating temperature of a cathode is determined by underheating the cathode incrementally and recording the change in cathode current with all other electrode voltages fixed. The minimum operating temperature is just above the knee of the current. Most electron guns also show some change in current with cathode temperature above the knee due to mechanical spacing changes due to thermal expansion. We can identify these mechanical changes by repeating the experiment at the half current level and plotting the results on semilog graph paper as shown in Figure 6. If the slope above the knee is the same for both current levels it must be due to mechanical changes.

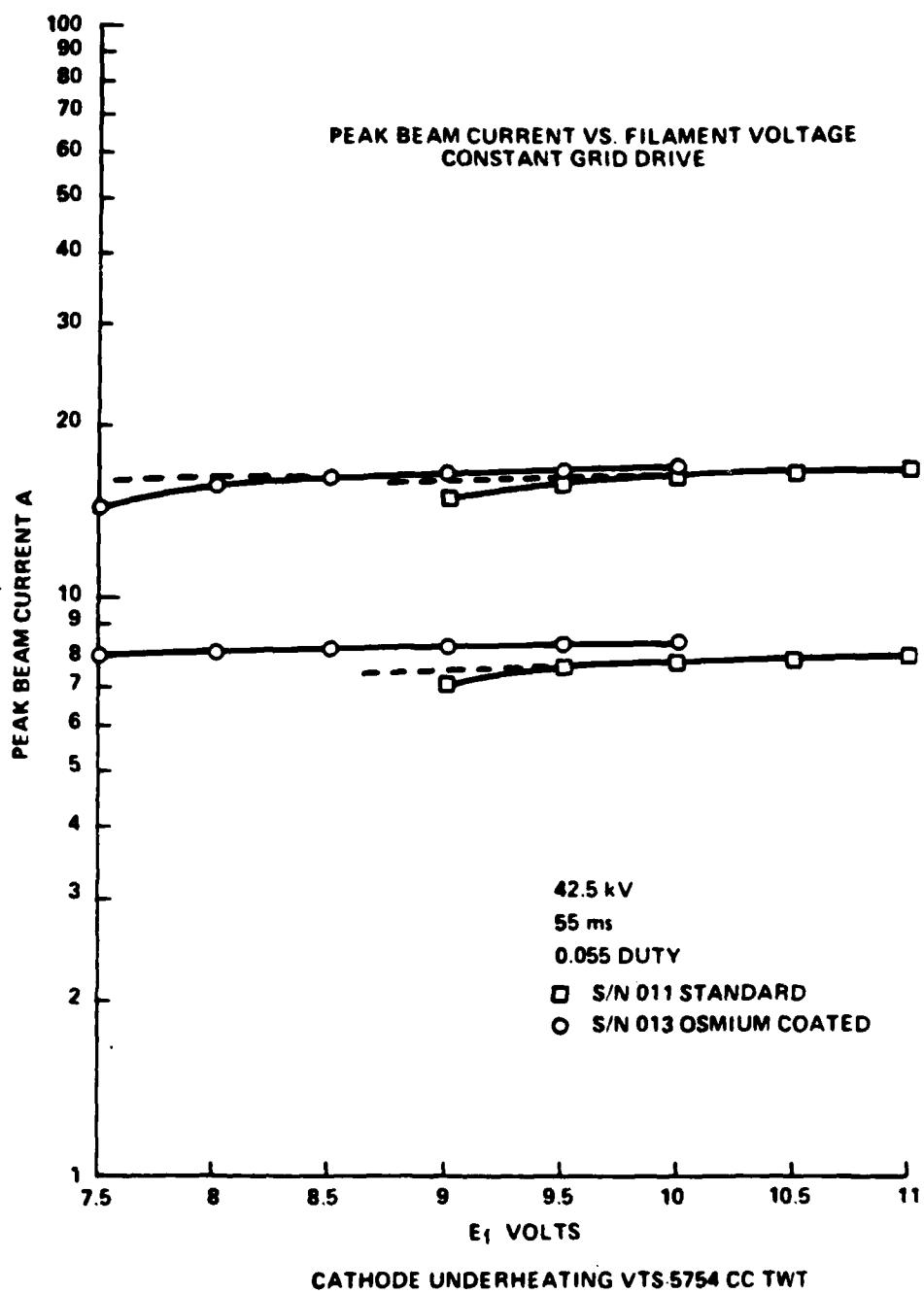


Figure 6. Peak Beam Current vs Filament Voltage Constant Grid Drive

The results for the standard dispenser cathode are normal for this current density. The displacement of the knee toward the lower temperature for operation at half current is normal.

The data shows the operating temperature for the coated cathode is 85°C less than the standard at 80% of the heater power from engineering data taken during the original gun development.

FUTURE PLANS

The collector will be redesigned to reduce the interelectrode capacitance. The diameter will be reduced since the major portion of the capacitance is in the annular portion between the collector body and the insulator support. The diameter will be reduced significantly to move a microwave resonance which is just below the band to just above the band. The change in size will not reduce the reliability of the tube since the existing design is used on S band tubes rated at several times the required duty factor. The first tube will be rebuilt using the smaller collector. If it passes all electrical tests, it will be final dressed and shipped to HAC for compatibility testing. The second tube will be built, tested and environmentally tested. No difficulties are expected on environmental testing since the basic tube and the new gun test vehicle have both passed the full environmental testing. This tube will also be shipped to HAC after completion of the environmental testing.

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